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The evolution of the market for commercial computerized physician order entry and computerized decision support systems for prescribing.

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ABSTRACT

Objective To understand the evolving market of commercial off-the-shelf Computerized Physician Order Entry (CPOE) and Computerized Decision Support (CDS) applications and its effects on their uptake and implementation in English hospitals.

Methods Although CPOE and CDS vendors have been quick to enter the English market, uptake has been slow and uneven. To investigate this, the authors undertook qualitative ethnography of vendors and adopters of hospital CPOE/CDS systems in England. The authors collected data from semi-structured interviews with 11 individuals from 4 vendors, including the 2 most entrenched suppliers, and 6 adopter hospitals, and 21 h of ethnographic observation of 2 user groups, and 1 vendor event. The research and analysis was informed by insights from studies of the evolution of technology fields and the emergence of generic COTS enterprise solutions.

Results Four key themes emerged: (1) adoption of systems that had been developed outside of England, (2) vendors' configuration and customization strategies, (3) localized adopter practices vs generic systems, and (4) unrealistic adopter demands. Evidence for our over-arching finding concerning the current immaturity of the market was derived from vendors' strategies, adopters' reactions to the technology, and policy makers' incomplete insights.

Conclusions The CPOE/CDS market in England is still in an emergent phase. The rapid entrance of diverse products, triggered by federal policy initiatives, has resulted in premature adoption of systems that do not yet adequately meet the needs of hospitals. Vendors and adopters lacked understanding of how to design and implement generic solutions to meet diverse user needs.

Keywords: Computerized Physician Order Entry, Computerized Decision Support, CPOE/CDS market challenges, health information infrastructures

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INTRODUCTION

Computerized Physician Order Entry (CPOE) and Computerized Decision Support (CDS) systems have the potential to deliver many benefits.¹ Stakeholders managing health systems in many countries have invested substantial efforts to implement and deploy such systems.² The United States has been among the leading countries in deploying these systems in hospitals.² England has similarly invested considerable resources in commercial off-the-shelf (COTS) CPOE and CDS systems. Calls by the National Health Service (NHS) in England to improve the quality, safety, and efficiency of healthcare, have promoted considerable interest in the timely implementation of these systems, which in the United Kingdom are more commonly referred to as “ePrescribing.”^{3,4}

These systems are well established in England’s primary care,^{5,6} and several attempts have been made to further implement them in hospitals. A key national initiative was the National Programme for Information Technology (NPfIT), in which selected software applications were to be centrally procured and implemented.^{7,8} However, NPfIT encountered numerous problems and the Department of Health instituted a change of direction toward local selection of systems by individual hospitals.⁸ This move has stimulated competition and resulted in hospitals being confronted by a range of vendor options, none of which are currently perceived as fully meeting the needs of the English market.³ Similar problems were initially encountered in the US market.⁹

The CPOE/CDS market in England is faced with substantial uncertainty and is currently undergoing rapid change and evolution.^{2,3} Our earlier work has highlighted the move away from “home-grown” to COTS systems, prompted by the very substantial costs associated with developing and maintaining bespoke applications, and problems with limited interoperability between different hospital systems.^{10,11} Standardized COTS systems, built around generic models of the user organization, may however be far removed from local workflows, necessitating considerable efforts to adjust local working practices and/ or to reconfigure and customize software.^{12,13} The lack of maturity of systems, their limited tailoring to the English context, diversity and ambiguity of options, and difficulties achieving change in long-established organizational practices all contribute to the challenges that hospitals face in realizing benefits.^{3,4,14,15,16}

This paper aims to improve understanding of the state of development of the CPOE/CDS market, encompassing both vendor and adopter perspectives in relation to the evolution and maturity of the market, and its consequences for the pace and success of implementation of COTS systems in NHS hospitals. This work is timely, as it has the potential to inform policy and practice in relation to the growing investments being made in procuring and implementing systems not only in England, but also in many other high- and middle-income countries.

DESIGN AND METHODS

We utilized a qualitative research design, building on earlier studies of the current status of the English hospital CPOE/CDS market,^{3,4} collecting data from both vendors and adopters.

Theoretical Framework: Understanding the Evolution of Technology Markets/Fields

In order to understand the evolution of the CPOE/CDS market in England, examination of its current stage in the technology development cycle is helpful. Scholars from various disciplines have advanced staged models of the evolution of industrial sectors and products, which characterize progression of the markets with respect to various factors such as the number of vendors, the range of design models, and innovation patterns over time.¹⁷ Agarwal and Tripsas¹⁸ offer a three-stage model of product and market evolution: emergence/ growth, shakeout, and maturity. In the emergence/growth stage, there is a high uncertainty on both the technology supply and demand sides. Many firms may enter the market. Products are adopted unevenly, and as products become established, dominant models start to emerge. Customers’ expectations become clearer and their preferences become stabilized, leading to a shakeout in the range of firms and products. Finally, in the mature phase, the technological and competitive environment stabilizes. Product innovation is overtaken by the rationalization of supply of standardized solutions.¹⁸

Studies of the provision of application software as “packaged” COTS solutions have highlighted difficulties faced by adopters in assessing the fit to their needs of these complex nonmaterial products—particularly in the early, emergent stage of the product lifecycle when there is limited understanding of the overall utility of the application class and the strengths of particular products. Vendors conversely need to understand the diverse practices and requirements of potential users and develop “generification” strategies that can cater

for this range.¹³ The emergence of dominant designs and consensus about the characteristics of a technology help to ameliorate these uncertainties in design and procurement faced by vendors and adopters.^{12,19,20} However, commodification pressures toward standardization may be reversed by further— particularly discontinuous—innovation. Thus changes in technological solutions and organizational goals and shifts to new market segments may reverse maturation and take the product back to the emergence stage.²¹

Institutional Review Board Approval and Ethical Considerations

This study is a part of a national research program investigating the implementation and adoption of ePrescribing (CPOE/CDS) systems in English hospitals, which received ethical approval from The University of Edinburgh's Research Ethics Committee. We also received guidance from the NHS Health Research Authority National Research Ethics Service (NRES) Committee London City and East that the study did not require review from an NHS ethics committee.

Sampling and Recruitment

The data obtained for this work is composed of publicly available documents and semi-structured interviews with participants from vendor and users who had given their written informed consent to participate. We also collected data from observation of user groups (periodic meetings organized by vendors which brought together users from across the country and other third-party organizations interested in their products) and a meeting organized by our project which brought together six vendors of CPOE/CDS systems in England. Participants in the user groups and this vendor event gave verbal/signed consent to be observed for this study. Interview and observation data were anonymized for analysis. Building on our recent survey of the current status of the English CPOE/CDS market, we developed a purposive sampling framework of current vendors and adopters of various CPOE/CDS systems in English hospitals to provide a multi-perspective view.^{3,22,23}

In order to develop a comprehensive picture, our purposive sample included at least one vendor or adopter from each system type within our typology that distinguished: standalone systems, modules within an integrated system, and distributed functionality among several modules.³ This included both established and more recently emerging products. Apart from one widely adopted UK system and an Italian system, the majority of systems examined come from the United States.

Potential respondents were approached in person or by e-mail. In total, we contacted 8 vendors, and 8 hospitals that had implemented or were in the process of implementing CPOE/CDS. Of these, 4 vendors and 6 hospitals agreed to participate. These 10 organizations fulfilled our requirement of having at least 1 vendor or 1 adopter from each of the CPOE/CDS types. In each case, we used purposive sampling to identify at least 1 person who had been involved in implementation of the system in English hospitals (a member of the project management team which ranged from doctors and pharmacists in adopter sites to project managers in vendor sites). This allowed us to investigate both vendor and adopter perspectives on the possible influence of the type of systems and the stages of their lifespan in England.

Data Collection

Our data collection methods consisted of semi-structured interviews and ethnographic observation. The study team benefits from over 40 years of cumulative experience in conducting and analyzing qualitative research in health and other sectors. The use of qualitative and ethnographic methods in the study of technology in health contexts is potentially very valuable in addressing emerging developments which are subject to uncertainty and divergent perspectives which can otherwise be hard to understand.²⁴ This combination of methods enabled us to investigate the reported experience of different entities as well as the nature of the interactions involved in adoption and implementation of systems in England. It also allowed us to triangulate results to facilitate credibility of our findings.²⁵

The interviews were semi-structured, with the interview guide focusing on 4 main areas: (a) the current status and development trajectory of CPOE/CDS systems in England; (b) strategies in design, development, and adaptation; (c) problems faced during implementation and their possible causes; and (d) the vendor-user relationship throughout the project lifecycle. The interview guides were tailored to the roles of individuals and further refined throughout the research based on the findings of prior interviews. The interviews ranged from 45 min to 2 h.

Three of our 4 selected vendors held English user group meetings. To provide wider context and aid the interpretation of our data, we requested to attend and observe those meetings, which offered particular opportunities to observe directly how user requirements and concerns were articulated through the user group and vendor responses to these. Two vendors agreed to allow access. Data from user group meetings consisted of researcher field notes around three main areas: (a) the technological contents of the discussion; (b) supplier-user relationships; and (c) decisions being taken.

We also observed a vendor event. This event gathered vendors to discuss their experience of implementation of CPOE/CDS system in English hospitals and discuss their concern and challenges in this process. Researcher field notes were recorded around 3 main themes: (a) challenges and opportunities for vendors from the early stages of project initiation to implementation, (b) vendors' experiences of go-live and system stabilization, and (c) vendors' views on system optimization and enhancements.

Data were collected over the period from October 2012 to October 2014. The interviews were audio-recorded and transcribed verbatim. One interviewee from the vendor group preferred not to be directly quoted, but nevertheless agreed for their views to be accounted for in the analysis. We continued data collection until we judged that no new themes were identified and saturation was reached.²⁶

Data Analysis

Data collection and analysis took place simultaneously to allow emerging themes to be fed back into future data collection. The analysis was performed using a thematic approach. We began with an inductive analysis of the data collected from different sources to identify patterns of emerging issues. This involved reading each interview, comparing transcripts and "searching across data sets" to find "patterns of meanings."²⁷ The codes were then grouped into themes. In forming each theme we cross analyzed vendor and adopter quotes to incorporate both viewpoints.

RESULTS

We interviewed 11 individuals from 10 organizations (4 vendors and 6 adopter hospitals) and performed 21 h of observation of user group and vendor events. We identified 4 key tensions in the design and implementation of CPOE/CDS systems concerning the more or less diverging perspectives of vendors and adopters, highlighting tensions and the strategies being pursued to ameliorate these.

Adoption of systems that had been developed overseas

We have previously highlighted that most systems available in England originated in other countries.³ Several adopters stated that implementing such systems in English hospitals could be problematic "*as their [US] way of working is very different to the UK based working.*" (Adopter Interview, P2). The lack of alignment between system functionalities and internal hospital processes such as workflows and medicines practices was seen as a major barrier to implementation by adopters.

... [Product Name] is a U.S. system and it works very well for a U.S. hospital, but some things in the U.K. are quite different, specially around medicines practices and we are still working with [Supplier Name] to see if we can get some of their products changed to better reflect our workflow (Adopter Interview, P4)

Similar problems have been observed in the adoption in Dutch hospitals of US solutions due to differences in workflow and practices as well as language.²⁸

Vendors were aware of these national differences and highlighted their efforts to tailor their product to the English context.

An interface to a formulary vendor for medications is standard in the US but we obviously had to go above and beyond, knowing that there are different requirements, there's different information on drugs in the U.K (Vendor Interview, P6)

While some overseas vendors (particularly those with limited presence in the English market) appeared reluctant to invest the significant resources needed to implement these changes, others (and particularly those with a larger share of the market) were deploying strategies to create England-specific versions of

their products. In localizing the systems, they were undergoing multiple cycles of modification. However, with only a handful of implementations in English hospitals, most systems were seen as still in the early stages of being “Anglicized.” This is a concept that was coined by UK health professionals to highlight difficulties in adopting organizational concepts²⁹ and more recently information systems^{30,31} arising from the United States with its different institutions and practices. Here we use the term more generically to refer to the customization of international systems for the UK market.

One example, which highlights differences in secondary care between the UK and United States in the processes by which medications are given to patients to take home as they are discharged is “to take out” (TTO) medication. While in the United States discharged patients receive a print out of their medication which they can fulfil at any pharmacy, in the UK, before the patient is fully discharged, doctors prescribe “take out” medications and patients need to go to the hospital pharmacy to pick up the orders.

... we have our own like UK ring, like the ability to place a TTO [To Take Out] medication order. That requirement does not exist in America, you cannot place a TTO order in the system in the States but in our [UK] ring you can so that's like one kind of big custom that we've done for our UK sites here ...

There was thus a national requirement to modify the US package to transfer such prescriptions electronically to the pharmacy and distinguish them from inpatient medications. The vendor achieved this by adding customized “flags” onto the package’s existing process for an “ambulatory medication order.”

[We] still utilise the system kind of how it's intended to be used but deliver what our customers [in the UK] need and it was to create an additional flag on that ambulatory medication order that if this flag exists the order gets sent electronically. So in the US system there is physically no way to send an ambulatory medication order to the pharmacy system, we created a customised, you know, method of delivering that order so that pharmacists see a TTO order on their list and they know oh that was a TTO that was ordered not an inpatient medication.” (Vendor Interview, P7)

In the above example, “UK ring” refers to the Anglicized version of a US developed product. A new business process has been added to meet the English market requirement. However, our work suggests that efforts to develop generic Anglicized versions of products are still in their infancy.

... after several hospitals [in U.S.] were up running live and stable with the software that's pretty much the version that we took as our initial like U.K. kind of starting point And basically, where we started there were certain items that we knew were going to be different in the U.K. (Vendor Interview, P7)

This resulted in system architectures that were inadequate and/or sub-optimal for the English market. Users who were implementing international systems in the hope of achieving benefits of their advanced functionalities found themselves caught in an unanticipated and slow process of joint system (re)development with the vendor. Vendors were under pressure to tailor systems to reflect the national and local particularities of the English context. They were therefore confronted with the need to identify both: 1) the generic English hospitals’ needs and 2) the specific needs of diverse adopting hospitals.

Vendor configuration and customization strategies

Vendors of packaged solutions need to develop effective “generification” strategies for addressing demands from their diverse user-base for modifications and new functionality.¹² Rather than respond reactively to a flood of disparate modification requests, they need to develop and retain a vision for the software, and maintain control over the overall architecture of their product as it moves forward. This allows them to priorities change requests, identify those they are unable or unwilling to support, and those to be undertaken by adopters themselves. To achieve this, established software packages are designed around a basic set of functionalities: the “generic kernel.”¹³ The adopter organization can then configure systems by selecting from a library of “templates” encompassing typical work processes in the sector, constructed around these core functions, and configure them to meet their local needs. Such software packages are “user-configurable” to meet the needs of various environments. If these

predefined configurations are limited and do not meet users' needs, adopters may ask for software program changes. However, such local customization can adversely affect system upgrades and maintenance.²¹

We found that CPOE/CDS vendors had made uneven progress in developing genericification strategies for the English market. While some responded to user demands reactively (and often reluctantly), others were more pro-active in seeking user input into system design. As a result, some adopters observed that vendors "very rarely offer specific solutions" to their particular needs. On the other hand vendors explained that such needs might be "too specific" to be incorporated into the generic system. Moreover, feedback from user groups indicated that most solutions were viewed by adopters as "too limited" in terms of configurability (user allowed customizations) and customization. Hence there was an ongoing dispute between what users demanded as configurability and what vendors referred to as specific customization needs.

Localized adopter practices versus generic systems

Implementation of generic systems further foregrounded variations in local hospital practices. Operational differences between hospitals, which had not previously been evident, became visible. Participants, particularly from the vendor side, therefore highlighted the need to introduce best practice standards to the sector in order to be able to develop more generic systems.

... every NHS trust in the country considers themselves to be different ... if you give them a standard OBS [output based specification] ... they make it unique to them ... every question [on the OBS] has a nuanced, has a little twist in there ... (Comment by vendor in vendor event)

The lack of standard practices became even more apparent with systems with higher levels of integration.

Unrealistic adopter demands

A potential underlying reason for many of the challenges identified may be the lack of user awareness surrounding the characteristics of packaged applications, resulting in unrealistic expectations. For example, the majority of users interviewed expressed a desire for local practices to be directly incorporated into the system.

... we are all doing the same job but we are managing the processes differently, so when we implement technologies we all want to implement it in our own way (Adopter Interview, P1)
... some of the changes we are asking [Product_Name] for are things that individual Trusts [hospitals] do ... (Adopter Interview, P4)

Vendors referred to these expectations as "over-aspirational functional specifications" (vendor comment at vendor event). For instance in user group meetings we observed cases where some users asked for a change of color for particular types of text on the screen, or a reduction in the number of clicks needed to perform certain tasks. The former might be simple to implement (though arguably users would quickly get used to this) while the latter might require more complex and potentially costly changes in source code.

... if I want the colour of the medication name to turn blue. OK well why do you want it to turn blue, do you really want that or do you just want something about it to be noticeable? Does it have to be blue; it's really just about opening that line of communication and figuring out well what's the need behind what you're saying. (Vendor Interview, P7)

Some adopters held (unrealistic) expectations that interfaces would be designed around specific methods of working in their hospital. The key challenge stemmed from the diversity of modification requests arising in an *ad hoc* manner from various groups of users. This posed multiple conflicting demands on developers.

To avoid such "untamed" unrealistic adopter demands, vendors identified the need to build alignment from the earliest opportunity between user expectations and actual system purposes and functions. There were also difficulties within hospitals in fully specifying system requirements for procurement. This led some adopters to propose direct links between the vendor and the hospital to help elicit their specific requirements (though this could run counter to the "arms-length" relationships required by tendering and contract management processes):

So companies I've worked for before have always had [. . .] a user that partly worked in the Trust [hospital] and partly worked for them [in the vendor company] so that they are a current user. (Adopter Interview, P2)

DISCUSSION

We identified several tensions in the design and implementation of CPOE/CDS systems in England:

1. the *ad hoc* management of user modification requests has proved problematic,
2. many products are limited in configurability and need to be customized to suit the needs of adopters and Anglicized versions of foreign developed packages have not yet been stabilized,
3. adopters contrasted the specificity of their work practices to generic vendor offerings, and
4. adopters often had unrealistic demands—for example, in terms of the level of specificity of local practice that packaged applications would catering for.

Progress with procuring and implementing CPOE/CDS applications in England is proceeding slowly. This may be due to the fact that the market is still in an early stage of emergence/growth.¹⁸ Despite the presence of various vendors, each has a relatively small number of implementations in progress and there is high technical variety in terms of system architectures and features.³ Products vary significantly in function and there is, to date, little evidence of the emergence of *de facto* standards or “dominant designs” in the English market,^{18,32} although existing international research has repeatedly highlighted desirable features of systems.^{33–39} Our previous work has shown that the absence of agreed national guidelines has resulted in diverse adopter procurement strategies and largely *ad hoc* vendor responses to end-user requests.⁴⁰

The limited adopter understanding of available options and the heterogeneity of user demands to modify vendors' products could lead to ambiguity in characterizing the target product or rejection of systems with standardized modules or interfaces.^{18,41–43} A lack of clear user preferences,⁴⁴ the existence of varied workflows,^{15,34} and the diversity of offerings from vendors exemplifies a market that is still in the emergence/growth stage. This is particularly noteworthy given that effective CPOE/ CDS requires fit between user workflows and vendors' products.^{15,28}

Implications for Policy and Practice

Another way in which the field appears immature is that it has not yet developed structures and actors to mobilize consensus and set the boundaries of technology—a role carried out in other sectors by industry analysts like Gartner¹² and by entities such as the Health Information Technology Standards Committee, certification criteria and certifying organizations in the United States. Guidelines based on successful implementation experience may help reduce procurement uncertainties—for example, by enabling development of generic cases for innovations, creating a space for comparison of different artefacts and vendors, and helping users come to more realistic and realizable expectations about CPOE/CDS functionalities and their effective deployment.

We observed a misalignment between the functionality offered by generic packages and the requirements of adopting organizations.^{34,45} Sustained adopter pressures for customization left little space for vendors to achieve effective generification strategies. To overcome this, adopters need to better understand vendors' packages and associated opportunities and challenges.

There is a need for more effective accommodation between the vendors' generification strategies and diverse localized hospital practices. This can be achieved by adhering to configurability principles by developing systems in a way that caters for diversities in workflows and operations.^{46,47}

Finally, there is a need to clarify the technological field around CPOE/CDS systems. This calls for engagement and consensus not only between adopters and vendors, but also larger communities including policymakers, field experts, and intermediaries such as industry analysts and implementation consultants.

A more specific implication for policy and practice concerns the need for more gradual development of this immature technology market. Thus, rather than seeking rapid large-scale implementation of their products, vendors may need to take a more deliberate and purposeful approach to enter new national

markets to accommodate for differentials in processes and practices. For CPOE/CDS systems this might include a two stage implementation plan: basic (comprising drug-allergy checking, basic dosing, formulary decision support, and checks on duplicate prescribing, and drug–drug interaction) and advanced (comprising variable range dosing, interactions with laboratory testing, and drug–disease contraindication checking).³³

Strengths, limitations, and future research

Our work provides significant insights into why the rapid entrance of commercial CPOE/CDS systems into the secondary care market in England was followed by a slow and often difficult adoption experience. Conducting a study that involved both vendors and adopters of the technology helped us gain an understanding of demand and supply issues. Involving several organizations in the investigation allowed us to gather perspectives from adopters and vendors of different types of systems originating from a variety of countries.

There are a number of limitations to our study, including our theoretical framework. While there is research into how vendors develop packaged solutions products for diverse users through (generification) strategies and linkages with adopters, we do not yet have systematic understanding of how these operate at the level of technology fields/ markets. The maturity of a technology field seems to be an important factor underpinning the rate and success of implementation. And the procurement of integrated information systems seems to display continued challenges. Further work is needed addressing organizational and sectoral characteristics in tandem.

Our work has highlighted particular issues arising when systems that originated in one national context are applied elsewhere.¹³ This issue besets attempts to implement, in the UK, hospital CPOE/CDS systems arising within differently organized health services. Globalization of supply, driven in part by the scale of investment required, gives added importance to this topic – with many applications being offered more widely across the English speaking world. Translation is not just a linguistic matter,²⁸ but depends also upon detailed differences in work practices, information processes, national and organizational cultures, and contextual factors that may not be readily appreciated in advance. More systematic cross-national research is needed into increasingly globalized system development and implementation to give insight into market adaptation and systems adoption.

As we have highlighted, the CPOE/CDS market in England is still in its emergence phase, with many new vendors and hospitals in the early stages of adoption. Hence, our sample consisted mainly of early adopters. Although these user organizations were not necessarily representative of all hospitals in England, they provided useful insights into some of the most important issues arising when a new technology enters the health sector. Furthermore, as the technological field around CPOE/CDS is not yet well established, other currently unknown actors may emerge to influence the growth of these systems. We note the continued dynamism of electronic health applications that may further shape the field, including extension in technical functionalities and increasing integration between applications. This highlights the need to continue to independently evaluate this rapidly evolving landscape. We have provided a starting point for this work.

CONCLUSIONS

This paper explored the state of development of the CPOE/CDS market and its the consequences for the implementation of COTS systems in NHS hospitals in England. Though system procurement in NHS England became decentralized again, following the demise of NPfIT, it continues to be shaped by strong national incentives, particularly for CPOE/CDS. Diverse products have entered the market. However neither developers nor adopting organizations seem adequately prepared for the complexities of transformations required. Although policy incentives can be effective in promoting adoption,² they may also have accelerated premature procurement of immature solutions. Vendors may need to adopt more strategic long-term (e.g., generification) approaches to the development of their offerings in catering for diverse needs. Adopting hospitals need to have more realistic expectations in relation to packaged applications with limited configurability. Mechanisms to bridge the gap between generic, standardized technological solutions and local needs will need to be developed in order to support the co-evolution of organization and technology.

It is further important to remember that CPOE/CDS is not a final stage, but serves as an important stepping-stone in the integration of healthcare systems and services, wherein such software functionality will become a fundamental part of health information infrastructures.³⁴ In order to achieve this, there is an urgent need to appreciate existing complexities and heterogeneities outlined in this work. These issues have international applicability as an increasing number of countries strive to stimulate CPOE/CDS adoption.^{2,48–50}

COLLABORATORS

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COMPETING INTERESTS

None.

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